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26. 7th Japan International SAMPE

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Key Words: *Carbon fiber-reinforced polymer (CFRP), Textile composites, Laminates, Smart materials/structure, Composite damage*

1. Summary

The 7th Japan International SAMPE was held November 13-16, 2001 in Tokyo. The conference, being a companion of the DURACOSYS-2001, covered broader subjects of composite materials. The sponsors were AOARD/AFOSR, AROFE, ONRIFO and the Business & Technology Daily News Ltd., The Japan Chapter of SAMPE. Business Center for Academic Society has published the proceedings, *"Information and Innovation in Composites Technologies."*
http://www.onrifo.navy.mil/Reports/2002/DURACOSYS2001.doc

Plenary Presentations

- *"Expanded Horizon in Materials and Processing –Unlimited Frontier-"* (J. C. Chang, Army Research Office, USA)
- *"Comparison of Low Cost Composite Manufacturing with Advanced Composites Processing Techniques"* (S. W. Beckwith, BTG Composites LLC, USA)
- *"Structuring Knowledge Project in Nanotechnology Materials Program Launched in Japan"* (H. Komiyama and Y. Yamaguchi, University of Tokyo: UOT)
- *"Advanced Composites Development for Aerospace Applications"* (D. R. Tenney and R. B. Pipes, NASA Langley Research Center, USA)
- *"A380-The Flagship For the New Century"* (J. Hinrichsen, Airbus, France)
- *"Experience of FRP Strengthening for Historic Structures"* (H. Katsumata and K. Kimura, Obayashi Co, Japan)
- *"New Examples of Composites Research"* (S. W. Tsai, et al, University of Stanford, USA)

Satellite Workshops (A-O) including 16 keynote presentations: number in parenthesis indicated number of presentations:

A: Smart Structures and Materials/Eco-Materials (22)

Embedding an optical fiber, shape memory alloy (SMA), dielectric and/or piezoelectric sensor in advanced composites enhances the integrity and performance. Japanese Smart Materials/Structures program, funded by the New Energy and Industrial Technology Development Organization (NEDO) under the Ministry of Economy, Trade and Industry (METI), is summarized in *http://www.onrifo.navy.mil/Reports/2001/SMS2000.doc*

Improving the Vibration Damping of Carbon Fiber-Reinforced Polymer (CFRP) Beam Structures by Use of Piezoelectric Polymer/Ceramic (T. Tanimoto, Shonan Institute of Technology)

CFRP laminates, with combined use of visco-elastic plastic/piezoelectric polymer (PVDF) film interlayers and surface bonded piezoelectric (PZT) ceramics, show stronger vibration damping than those with individually embedded PVDF or surface bonded PZT.

Impedance Change Method for Wireless Strain Measurement of Composite Materials (A. Todoroki, et al., Tokyo Institute of Technology)

Measurement of the impedance frequency enables to monitor the applied strain of composite materials, made up of steel wire reinforced tires. The new wireless impedance measuring system consists of low-cost sensor and oscillator circuit.

Development of an Aluminum Based Smart Composite with Embedded Oxidized Titanium Fiber (H Asanuma, et al., Chiba University)

Active Al based composites were fabricated by embedding surface-oxidized Ti fibers together with stainless steel wires in the Al matrix. The TiO_2/Ti fiber has multi-functions as a heater, temperature and strain sensor in the active composites.

B: Design and Manufacturing of Revolutionary Light Weight Aircraft Structures (22)

Microstructure and Mechanical Properties in the Friction Stir (FS) Welded Dissimilar Light Metals (N. Saito, et al., National Institute of Advanced Industrial Science and Technology)

FS welding was successively applied to 6061 and 5083 aluminum alloys. However, FS welded 6061/6061 and dissimilar 5083/6061 alloys show lower strength and ductility than the base materials.

Large Size Aluminum Precision Sand Casting Technology Development for Aircraft Primary Structures (A. Shibata, et al., Kobe Steel Ltd.)

Pressure support structure of D357 aluminum alloys, with the size of 1850 x 1520 x 350mm^3 and wall thickness of 2 mm, was fabricated using a precision sand casting method. The camber and over all distortions induced during post-cast annealing can be minimized by optimizing the fixing position with jigs.

Fatigue Life Prediction of CFRP/Metal Bolted Joint under Temperature Condition (N. Sekine, et al., Kanazawa Institute of Technology)

The fatigue life of bolted joints of CFRP/metals was estimated from constant strain rate tests at various temperatures by applying the time-temperature superposition principle. *http://www.onrifo.navy.mil/Reports/2002/CompDura/doc*

C: Development of Low Cost Composite Structures (13)

Development of Thermoplastic Polyimide (PIXA-MT3) Composite (Y. Honda, et al., Fuji Heavy Industries Ltd.)

Mitsui Chemicals Inc. has developed a modified thermoplastic polimide (PIXA-MT3) with good resistance to solvent and thermal cycling as well as processibility. Void free PIXA-MT3 based CFRPs, which were consolidated above 340^{o}C for 10 min in vacuum, followed by annealing at 360^{o}C for 240 min, have better thermal cycling resistance in a wide temperature range from -54^{o}C to 177^{o}C than conventional PIXA-M based composites.

Folded Honeycomb Core Materials for Automotive and Aerospace Applications (J. Pflung, et al., Katholieke Universiteit Leuven, Belgium)

Thermoplastic folded honeycomb (Thermhex) cores have hexagonal cells and closed skin strips, which allow fast and reliable bonding of the skins onto the core without an additional glue layer. The production steps are composed of (1) forming half-hexagonal shape by deep drawing or by vacuum thermoforming, (2) folding of the half-hexagonal web to build the honeycomb core, (3) internal bonding of the honeycomb core by thermal fusion and (4) lamination of thermoplastic skins onto the honeycomb core.

Well-Processable Matrix Resins with Less-Flammability for Vacuum-Assisted Resin Transfer Molding (VaRTM) (N. Miyoshi, et al., Toray Industries Inc.)

Phenolic resins have better heat resistant and less flammability than cyanate ester resins. The heat resistance of the cyanate ester is improved by adding organometallic and hydroxy compounds. Sandwich-structured panels of phenolic and modified cyanate ester resins processed by a VaRTM method have no voids or cracks and good surface quality.

H: New Trends in Polymer Composites and Their Fibers (14)

A Low Temperature Cure Material for Large Scale Prototype Model Construction (K. Mita, et al., Mitsubishi Rayon Co. Ltd.)

A new class epoxy resin (#850) has been developed, which is curable at low temperatures. Typical cure cycle of the #850, leading to low void formation, is the duration of 5 h at 90^{o}C in vacuum followed by a freestanding post-cure at 180^{o}C for 4 h. Polyacrylonitrile (PAN) based carbon fiber (CF)/#850 composites possess similar mechanical properties to CFRP with conventional epoxy resin (177^{o}C curing).

Interplay Hybrid Laminates with Improved Flexural Impact Resistance (S. Takemura, et al., Nippon Mitsubishi Oil Corporation)

The impact failure energy of PAN-based CF laminates (T700S) under flexural loading is three-fold increased by reinforcing T700S with a thin layer of low modulus (50 GPa) CF (XN-05), which has high compressive failure strength.

I: Ceramic Matrix Composites and Carbon/Carbon Composites (15)

Fiber/Matrix Interface Shear Strength Measured In-situ for SiC/SiC Composites with Different Matrices and Interfaces (I. J. Davies, et al., Kyoto Institute of Technology: Keynote)

The shear strength at the interface of SiC/SiC composites was estimated using in-situ fiber strength and fiber pullout length methods. The interfacial shear strength of unsealed composites at 1100 & 1200^{o}C in air 10-times increases due to the interfacial oxidation than that at room temperature.

High Temperature Creep Deformation and Thermal Stability of 3-D Woven Tyranno ZMI Fiber/Si-Ti-C-O Matrix Composite (Y. Ohsawa, et al., University of Electo-Communication)

3-D woven Tyranno ZMI fiber (Zr containing SiC: product of Ube Industries Ltd.)/Si-Ti-C-O matrix composites do not show steady state creep deformation at 1573-1723K in air. This finding is related to the composite decomposition, resulting from the pyrolytic reaction, and the grain growth of SiC.

Ceramic Coatings for Oxidation Protection of C/C Composites (T. Aoki, et al., National Aerospace Laboratory)

In order to mitigate the thermal expansion mismatch, two coating systems have been applied over CF reinforced carbon substrate. Multi-layered coatings, consisting of thin SiC (<5-7 μm) and pyrolytic carbon layers (125 μm thick) with sinusoidal surface/interfaces, eliminate through-thickness cracking due to a reduction in the thermal stress.

J: Metal Matrix Composites and Related Materials (17)

Corrosion Mechanisms of Metal-Matrix Composites (MMC) (L. H. Hihara, University of Hawaii: Keynote)

The corrosion behavior of MMC is mainly controlled by the galvanic corrosion at the interface of the matrix and fibers. The galvanic corrosion rate between 6061-T6 Al alloys and various reinforcement in aerated 3.15 wt.% NaCl solution is ranked as following: P100 graphite fibers > carbon-cored SiC with ends exposed > tungsten-cored boron with ends exposed > hot-pressed (HP) SiC > Si.

Application of Intermetallic Compound Parts by Spark Plasma Sintering (SPS) Process of Cu-Al Elemental Metal Powders (T. Nakamura, et al., Shizuoka University)

Powder mixtures of Cu-33at.%Al milled by mechanical alloying were consolidated at 800^{o}C for 9 min under 50 MPa using a SPS method. SPS processed alloys with intermetallic compounds of Cu_9Al_4 and CuAl depict high hardness (Hv = 700) and compressive fracture strength (1 GPa).

K: Textile Composites (23)

Cost Effective Manufacturing Technology for Knitted Fabric Composites (K. Nishiyabu, Osaka Prefectural College of Technology: Keynote)

Weft-knitted fabric reinforced thermoplastic composites were manufactured using three stage processes: knitting, impregnation/stock fabrication and press forming. Co-knitted fabrics with 3-D structure, made up of thermoplastic and reinforcing yarns, were simultaneously impregnated and press-formed.

Mechanical Properties of Knitted Fabric Composites with Hybrid Matrix Layer (A. Nakai, et al, Kyoto Institute of Technology)

Various hybrid knitted fabrics composites were fabricated, composed of vinylester or unsaturated polyester matrix and flexible interphase layers of unsaturated polyester. The bending strength of the fabric composites increases with increasing Young's modulus.

M: Modeling and Simulation in Composite Mechanics (16)

Analytical Prediction and Experiment of Transverse Lamina Cracking in Multidirectionally Reinforced Symmetric Laminates (S. Abe et al., University of Tokyo)

Transverse laminar cracking is analyzed using two failure criteria under tensile/shear mixed modes. The energy and stress criteria control the onset of transverse laminar cracks for the thin and thick 90^{o} ply groups, respectively.

Damage Accumulation in Composite Laminates under Quasi-Static Transverse Loading (Y. Aoki and H. Suemasu, Sophia University)

The mechanism of damage accumulation in laminated composites during impact loading is analyzed in terms of the radial distribution of strain energy release rate controlling delamination using finite element analysis.

A Study of Bridging the Gap between Atomistic and Mesoscopic Simulation for Materials Design (S. Yamamoto and S. Hyodo, Toyota Central R & D Laboratory)

This is an interesting paper, which attempts to fill the gap between the atomistic and mesoscopic simulation to predict molecular structure at the interface of immiscible polymer blend systems. In this study, the dissipative particle dynamic technique, i.e., mesoscopic simulation, incorporated with the molecular mechanics and dynamics that determine the mixing energy, is applied to define the molecular structure.

N: New Trends in Damage Identification and NDI (12)

Ballistic Impact Behavior and Properties of Structural Ceramic Materials (H. Kasano and O. Hasegawa, Takushoku University)

The impact perforation behavior of SiC and zirconia plates was in-situ observed using a digital image system. The ballistic limit and residual velocities of the projectile after perforation were estimated with the aid of analytical modeling.

O: Student Session (15).

Mechanical Properties of SMA Fiber/Epoxy Composite (A. Kobayashi, et al, Tokyo University of Science)

Specimens, in which pre-strained and acid-cleaned/heat treated SMA fibers are embedded, show the highest failure stress of epoxy resin due to the recovery stress of SMA and after-curing effect.

D: New Materials in Space Vehicles (20)
E: Composite Applications to Infrastructure (11)
F: Composite/Plastic Applications to Transportation Vehicles (8)
G: Composite Applications to Sport and Leisure Goods (19)
L: Interface in Composites (7)

2. Background

The Japan International SAMPE Symposium has been held every two years since 1989. Among 234 papers, Japanese authors made the majority of the presentations while no papers from China and Korea were presented. Most of overseas presentations were invited plenary and keynotes. This symposium is essentially considered a domestic meeting.
http://www.onrifo.navy.mil/reports/2001/ACCM-2000.doc

3. Assessment

Japanese companies like Toray Industries Inc. have produced high quality CF and resins, which are major composite constituents. However, there are not many innovative designs of advanced composites because aircraft and aerospace industries in Japan and Asian countries are not as strong as in the USA.

4. Points of Contact

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